LAMINATED CERAMIC ELECTRONIC PARTS

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to laminated ceramic electronic parts and more specifically to laminated ceramic electronic parts such as a laminated ceramic capacitor and a laminated varistor having a structure in which a plurality of internal electrodes are disposed so as to overlap each other via ceramic layers within a ceramic element composing the electronic part.

Description of Related Art:

Ins B17

A surface mounted laminated ceramic capacitor which is one of typical laminated ceramic electronic parts is constructed by disposing external electrodes 24a and 24b which electrically conduct with a plurality of internal electrodes 22 at both ends of a ceramic element (capacitor element) 23 having a structure in which the internal electrodes 22 are disposed so as to face each other via ceramic layers 21a within dielectric ceramic 21 and respective one ends of the internal electrodes 22 are led alternately to the opposite side as shown in FIG. 2 and is characterized in that it can obtain a large capacitance even though it is small.

By the way, with the miniaturization and the enhancement of capacity of the laminated electronic parts, the ceramic layer 21a within the laminated ceramic electronic parts such as the laminated ceramic capacitor have come to be thinned and a number of laminated layers thereof to be increased rapidly and those having a structure in which a thickness of the ceramic layer 21a

interposed between the internal electrodes 22 (effective thickness of element) is 5 μm and the number of lamination exceeds 100 have come to be put on the market.

The ceramic layer 21a has come to be thinned such that there is no big difference with the thickness of the internal electrode 22 in such laminated ceramic electronic parts and even one in which a rate of a total thickness of respective internal electrodes to a thickness of a ceramic element (chip) (thickness of internal electrodes (total)/thickness of ceramic layer) exceeds 0.30 has come to be provided.

B

Then, thereby, ~~a~~ sintering characteristic of the laminated ceramic electronic part, i.e. the product, is largely influenced by a sintering characteristic of a material of the internal electrode in a sintering process. As a result, there has been a problem that when the rate of the material of the internal electrode to the ceramic element increases, an incidence of delamination and crack increases in the sintering process, thus increasing a fraction defective and degrading the reliability. Further, such laminated ceramic electronic part has had a problem that it is liable to cause cracks when it receives a thermal shock.

SUMMARY OF THE INVENTION

B B B B

Accordingly, it is an object of the present invention to solve the above-mentioned problems by providing highly reliable laminated ceramic electronic parts in which delamination or ~~crack~~ cracking can be suppressed ~~from occurring~~ during ~~a~~ the sintering process and which excels in thermal shock resistance even if ~~a~~ the number of ~~lamination of~~ internal electrodes is increased and ~~a~~ the thickness of ~~a~~ the individual ceramic layers (located between the internal electrodes) is reduced.

3

In order to achieve the above-mentioned object, the present invention includes a ~~inventive laminated~~ ceramic electronic part having a structure in which a plurality of internal electrodes are disposed so as to overlap each other via respective ceramic layers ~~within a ceramic element~~ and the internal electrodes are led to terminals on the opposite sides of the ceramic element and in which each ~~per~~ layer ~~is characterized in that it~~ satisfies the following requirements:

(a) the ~~a~~ thickness of each respective ~~the~~ ceramic layer is 10 μm or less;

(b) the ~~a~~ number of ~~lamination of the~~ internal electrodes is 200 or more;

(c) the ~~a~~ ratio of the thickness of the internal electrodes to the thickness of the ceramic layers (thickness of internal electrode/thickness of ceramic layer) is between 0.10 and ~~to~~ 0.40; and

(d) the ~~a~~ ratio (volume of internal electrode/volume of ceramic element) of the total ~~a~~ volume of the internal electrodes to the ~~a~~ volume of the ceramic element (i.e., the combined ~~total~~ volume of internal electrodes and the ceramic material) is between 0.10 and ~~to~~ 0.30.

By satisfying the foregoing requirements, it ~~It~~ becomes possible to suppress delamination and cracking from occurring during the sintering process, to improve ~~the~~ thermal shock resistance and to provide a ~~the~~ highly reliable laminated ceramic electronic part even when the number of laminated ~~lamination of the~~ internal electrodes is increased and the thickness of the ceramic layer is reduced. ~~by satisfying the requirements of that the thickness of the ceramic layer is 10 μm or less; the number of lamination of the internal electrodes is 200 or more; the ratio of the thickness of the internal electrode to the thickness of the ceramic layer (thickness of internal electrode/thickness of ceramic layer) is 0.10 to 0.40; and the ratio of the volume of the internal electrodes to the volume of the ceramic element~~

4

(volume of internal electrodes/volume of ceramic element) is 0.10 to 0.30.

That is, it becomes possible to reduce ~~suppress~~ the influence of the sintering characteristic of the material of the internal electrode during the sintering process and to prevent delamination and cracking ~~crack~~ from occurring during the sintering process by controlling the ratio of the thickness of the internal electrode to the thickness of the ceramic layer (thickness of internal electrode/thickness of ceramic layer). It also ~~and it~~ becomes possible to enhance the strength of the laminated ceramic electronic part against thermal stress and to provide the highly reliable laminated ceramic electronic part by controlling the ratio (volume of internal electrodes/volume of ceramic element) of the total volume of the internal electrodes to the total volume of the ceramic element (i.e., the total volume of internal electrodes and the ceramic material).

The specific nature of the invention, as well as other objects, uses and advantages thereof, will clearly appear from the following description and the from the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING(S)

FIG. 1 is a section view showing a structure of a laminated ceramic electronic part (laminated ceramic capacitor) according to one embodiment of the present invention; and

FIG. 2 is a section view showing a structure of a prior art laminated ceramic electronic part (laminated ceramic capacitor).

DESCRIPTION OF PREFERRED EMBODIMENT

One preferred embodiment of the present invention will

be described below in detail. FIG. 1 is a section view showing a structure of a laminated ceramic electronic part (laminated ceramic capacitor in the present embodiment) according to the embodiment of the invention.

As shown in FIG. 1, the laminated ceramic capacitor is constructed by disposing external electrodes 4a and 4b, which are in ~~electrically conduct~~ electrical contact with a plurality of internal electrodes 2, at opposite ~~both~~ ends of a ceramic element e.g., a (capacitor ~~element~~) 3. ~~having a structure in which~~ The ~~the~~ internal electrodes 2 are disposed so as to face each other via ceramic layers 1a within a ceramic body 1 and a respective ~~one~~ end of each ~~the~~ internal electrode 2 is coupled to external electrode 4a or 4b. ~~are led to the opposite side alternately.~~

~~It is noted that in fabricating such a laminated ceramic capacitor, three kinds of~~ green sheets having a ~~whose~~ thickness after sintering of either ~~turn out to be~~ 9.8 μm, 6.2 μm or ~~and~~ 4.3 μm, ~~respectively, after sintering have been formed.~~ Then, conductive paste for forming the internal electrode was ~~has been~~ printed on one surface of the green sheets ~~such that they turn out to have thickness as shown~~ in Table 1. Then, after laminating and compressing them such that a number of lamination of the internal electrodes turns out to be 200, 200 laminations were compressed together and ~~they have been~~ cut into a predetermined size (length L = 3.2 mm, width W = 1.6 mm) to obtain laminates (non-sintered ceramic element).

After heat ~~Next, after~~ treating the ceramic element under predetermined conditions ~~laminate by heat~~ to degrease and ~~to~~ if sinter ~~under predetermined conditions~~, conductive paste for forming the external electrodes was ~~electrode has been~~ applied to opposite ~~on the both~~ ends of the sintered ceramic element. Finally, ~~Then, they have been~~ sintered to form the external electrodes and the laminated ceramic capacitor as shown in FIG. 1 was produced ~~has been obtained.~~

The ~~Then,~~ characteristics of each of the sample laminated ceramic

capacitors were tested to determine the ~~capacitor thus obtained, such as a~~ value of electrostatic capacity, the ~~to be obtained, a~~ value of insulation resistance, the ~~an~~ incidence of delamination, the ~~and an~~ incidence of cracking ~~crack on~~ the surface of the ceramic element during sintering and the ~~as well as an~~ incidence of cracking ~~crack~~ (incidence of thermal shock crack) when a thermal shock (_T = 350°C) is applied to the sample ~~have been studied~~. Table 1 shows the results ~~result~~ of these tests.

TABLE 1

+ +,0080

B

	Thickness of Ceramic ~~Light~~ Layer	Thickness of Internal Electrode	Ratio of Thickness of Internal Electrode	Ratio of Volume of Internal Electrode	Value of Electrostatic Capacity	Value of Insulation Resistance	Incidence of Delamination	Incidence of Crackings	Incidence of Thermal Shock Cracking
	(μm)	(μm)	(-)	(-)	(μF)	log IR	(%)	(%)	(%)
* 1	9.8	0.68	0.06	0.075	1.81	12.01	0.00	0.00	0.00
2	9.8	0.99	0.10	0.100	2.25	12.00	0.00	0.00	0.00
3	9.8	1.13	0.15	0.112	2.37	11.98	0.00	0.00	0.00
4	9.8	1.97	0.20	0.186	2.43	11.87	0.00	0.00	0.00
* 5	9.8	2.50	0.26	0.307	2.23	11.98	0.33	1.35	2.13
* 6	6.2	0.58	0.09	0.095	2.78	11.53	0.00	0.00	0.00
7	6.2	0.87	0.14	0.135	3.54	11.25	0.00	0.00	0.00
8	6.2	1.15	0.19	0.172	3.42	11.15	0.00	0.00	0.00
9	6.2	1.87	0.31	0.257	3.15	11.01	0.00	0.01	0.00
*10	6.2	2.40	0.38	0.310	3.07	11.07	0.53	0.97	0.54
*11	4.3	0.41	0.95	0.103	3.98	10.10	0.00	0.00	0.00
12	4.3	0.71	0.16	0.170	4.54	10.93	0.00	0.00	0.00
13	4.3	0.97	0.23	0.200	4.95	11.25	0.00	0.00	0.00
14	4.3	1.23	0.29	0.210	5.01	10.98	0.00	0.00	0.00
*15	4.3	1.65	0.41	0.310	4.99	10.33	0.13	0.52	1.58
*16	4.3	2.40	0.56	0.390	4.83	10.54	0.97	1.35	3.51

B

B

8

It is noted that in Table 1, those samples marked with * fall outside ~~are those out of~~ the scope of the present invention (comparative examples) and the other samples ~~are those~~ fall within the scope of the invention.

The "Ratio ~~Further, "Rate~~ of Thickness of Internal Electrode" is the ratio ~~rate~~ of the individual thickness of the internal electrode to each ~~the~~ individual thickness of ~~the~~ each ceramic layer (thickness of internal electrode/thickness of ceramic layer) and the "Ratio ~~and "Rate~~ of Volume of Internal Electrode" is the ratio ~~rate~~ of the total volume of the total internal electrodes to the total volume of the ceramic element ~~layer~~ layers (i.e., the total volume of the internal electrodes and the ceramic).

Ins B6>

Further, the ~~evaluating items and a~~ number of ~~evaluated~~ samples (n) B6 in Table 1 ~~has had the following relationship.~~

Electrostatic Capacity, Insulation Resistance: n=100, ~~Resistance~~ ~~n = 100~~

Incidence of Delamination and Cracking: n=500, ~~n = 500~~

Incidence of Cracking ~~Crack~~ due to Thermal Shock; n=500, ~~n = 500~~

As shown in Table 1, it has been confirmed that while (1) the value of electrostatic capacity is small in Sample No. 1 whose ratio ~~rate~~ of the thickness of the internal electrode is below that of the scope of the invention (0.10 to 0.40), (2) the value of insulation resistance is small in Sample No. 11 whose ratio ~~rate~~ of the thickness of the internal electrode exceeds that of the scope of the invention, and (3) the incidences of delamination, cracking ~~crack~~ and cracking ~~crack~~ due to thermal shock are high in Sample Nos. 5, 10, 15 and 16 whose ratio ~~rate~~ of the volume of the internal electrode exceeds that of the scope of the invention (0.10 to 0.30), the samples within the scope of the invention which satisfy the

requirements of that the ~~rate~~ ratio of the thickness of the internal electrode to that of the ceramic layer (thickness of internal electrode/thickness of ceramic layer) is between 0.10 ~~to~~ and 0.40 and the ~~rate~~ ratio of the volume of the internal electrode to the volume of the ceramic element (volume of internal electrode/volume of ceramic element) is between 0.10 ~~to~~ and 0.30 can obtain characteristics which are practically no problem with respect to the values of electrostatic capacity and of insulation resistance, cause no delamination nor ~~crack~~ crackings during the sintering process and cause no ~~crack~~ cracking due to thermal shock.

It is noted that while the present embodiment has been explained by exemplifying ~~the~~ a laminated ceramic capacitor, the present invention is applicable not only to ~~the~~ laminated ceramic capacitors but also to various laminated ceramic electronic parts such as a laminated varistor having the structure in which a plurality of internal electrodes are disposed so as to overlap each other via ceramic layers within the ceramic element.

The present invention is not limited to the embodiment described above also in other points. That is, it is possible to add various applications and modifications thereto within the scope of the invention with respect to the thickness of the ceramic layer, the number of lamination of the internal electrodes, the rate of the thickness of the internal electrode to that of the ceramic layer, the rate of the volume of the internal electrode to that of the ceramic element and the like.

As described above, because the inventive laminated ceramic electronic part is constructed so as to satisfy the requirements of that the thickness of the ceramic layer is 10 μm or less; the number of lamination of the internal electrodes is 200 or more; the ratio of the thickness of

the internal electrode to the thickness of the ceramic layer (thickness of internal electrode/thickness of ceramic layer) is 0.10 to 0.40; and the ratio of the volume of the internal electrode to the volume of the ceramic element is 0.10 to 0.30, it is possible to suppress the influence of the sintering characteristic of the material of the internal electrode during the sintering process, to prevent delamination and crack from occurring during the sintering and to enhance the strength of the laminated ceramic electronic part against thermal stress.

In accordance with the present invention ~~As a result~~, it ~~becomes~~ is possible to suppress delamination and cracking ~~crack~~ from occurring during the sintering process even when the number of ~~lamination of the~~ internal electrodes is increased and the thickness of the ceramic layer is reduced and to provide the highly reliable laminated ceramic electronic part which excels in its ~~the~~ thermal shock resistance.

While the preferred embodiment has been described, variations thereto will occur to those skilled in the art within the scope of the present inventive concept which is delineated by the following claim.